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For: INK-JET RECORDING APPARATUS, RECORDING METHOD AND RECORDING MEDIUM

SUBMISSION OF CERTIFIED TRANSLATIONS OF PRIORITY DOCUMENTS

Commissioner for Patents
Washington, D.C. 20231

Sir:

Submitted herewith are certified copies of the priority documents on which a claim to priority was made under 35 U.S.C. § 119. The Examiner is respectfully requested to acknowledge receipt of said priority documents.

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DECLARATION

In the matter of U.S. Patent
Application No.09/686,959
in the name of
SEIKO EPSON CORPORATION

I, the undersigned, Yumi HARABE, of 22-7, 3-chome, Kitazawa, Setagaya-ku, Tokyo, Japan, do hereby declare that I am the translator of the documents attached and certify that the following is a true translation to the best of my knowledge and belief.

Signature

Harabe
Yumi HARABE

Dated March 17, 2003

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PATENT OFFICE JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of
the following application as filed with this office.

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Applicant(s): SEIKO EPSON CORPORATION

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[Title of the Invention] INK-JET RECORDING APPARATUS

[What is claimed is]

[Claim 1] An ink-jet recording apparatus, which has a recording head that ejects ink from an ink reservoir and driving signal generating means that generates a driving signal for ejecting ink droplets, characterized by comprising:

an ink reservation amount obtaining means for obtaining an ink reservation amount in the ink reservoir;

temperature information storing means for storing head temperature information from temperature detecting means for detecting a temperature of the recording head;

a temperature change amount obtaining means for obtaining a temperature change amount of the recording head based on the head temperature information stored by the temperature information storing means; and

driving signal correction means for correcting the driving signal generated from the driving signal generating means,

wherein the driving signal correction means corrects the driving signal based on the temperature change amount obtained by the temperature change amount obtaining means and the ink reservation amount obtained by the ink reservation amount obtaining means.

[Claim 2] The ink-jet recording apparatus according to claim 1, characterized in that said temperature information storing means stores the head temperature information from the time when a power source is turned on.

[Claim 3] The ink-jet recording apparatus according to any one of claims 1 and 2, characterized in that said temperature information storing means stores the head temperature information in a waiting state of a recording operation.

[Claim 4] The ink-jet recording apparatus according to any one of claims 1 to 3, characterized in that said temperature information storing means keeps the stored head temperature information even after the power source is turned off.

[Claim 5] The ink-jet recording apparatus according to claim 4, characterized in that said temperature change amount obtaining means obtains the temperature change amount by using the head temperature information kept by the temperature information storing means when the power source is turned on again within a specified time after the power source is turned off.

[Claim 6] The ink-jet recording apparatus according to any one of claims 1 to 5,

characterized in that said driving signal generating means generates the driving signal including a driving pulse capable of ejecting the ink droplets, and

the driving signal correction means sets a driving voltage for the driving pulse based on the temperature change amount and the ink reservation amount.

[Claim 7] The ink-jet recording apparatus according to any one of claims 1 to 6,

characterized in that said driving signal generating means generates the driving signal including the driving pulse capable of ejecting the ink droplets, and

the driving signal correction means changes a waveform of the driving pulse based on the temperature change amount and the ink reservation amount.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to an ink-jet recording apparatus that ejects ink reserved in an ink reservoir such as an ink cartridge and an ink tank from a recording head.

[0002]

[Prior Art]

An ink-jet recording apparatus such as an ink-jet printer and an ink-jet plotter (hereinafter, referred to as a recording apparatus) comprises a recording head capable of ejecting ink as ink droplets, which is reserved in an ink reservoir such as an ink cartridge and an ink tank. In this recording apparatus, the recording head is made to move along a main scanning direction, and the ink droplets are ejected from the recording head so as to interlock with this movement.

[0003]

Incidentally, if an environmental temperature (for example, a room temperature) at a place where the recording apparatus is used is changed, an ejection amount of the ink droplets fluctuates since ink viscosity is changed. For example, when the environmental temperature is higher than a designed reference temperature, the ink viscosity becomes lower than a

normal state. Thus, when the ink droplets are ejected in a standard driving pulse, the amount of the ejected ink droplets becomes larger than a designed value. Conversely, when the environmental temperature is lower than the reference temperature, the ink viscosity becomes higher than the normal state. Thus, when the ink droplets are ejected in the standard driving pulse, the amount of the ejected ink droplets becomes smaller than the designed value. Such fluctuation of the ink amount is a cause of deterioration of image quality.

[0004]

Accordingly, in order to prevent the ink amount from fluctuating along with the change of environmental temperature, a recording apparatus is provided, in which a temperature sensor such as a thermistor is provided, for example, on a recording head or a carriage, and a driving signal that drives a piezoelectric oscillator based on head temperature information detected by the temperature sensor is corrected.

[0005]

In the recording apparatus, for example, when a head temperature information value is lower than a reference temperature, a driving voltage for a driving pulse included in the driving signal is made to be higher than a standard value. On the contrary, when the head temperature information value is higher than the reference temperature, the driving voltage for the driving pulse included in the driving signal is made to be lower than the standard value.

[0006]

[Problems to be solved by the Invention]

However, since the head temperature information used for driving signal correction is an environmental temperature, such as a room temperature, a difference may occur from an ink temperature reserved in an ink reservoir in some cases. This is because the heat capacity of ink is larger than the heat capacity of air, and because ink has a property that it is harder to heat and harder to cool down. And, when a difference exists between the head temperature information value and the ink temperature, it is difficult to make ink droplets uniform in a desired amount even if the driving signal is corrected based on the head temperature information.

[0007]

Such a phenomenon is prominent when a rapid temperature change occurs in a place where the recording apparatus is used, such as on an occasion that air conditioner is turned on in summer or heater is turned on in winter.

[0008]

The present invention was invented in consideration of the foregoing problems, and an object of the present invention is to provide an ink-jet recording apparatus that can make an ejection amount of ink droplets uniform even if a temperature change occurs in a place where the recording apparatus is used, and can obtain a recorded image of stable quality.

[0009]

[Means for Solving the Problems]

The present invention has been proposed to achieve the

above-described object. The invention described in claim 1 is an ink-jet recording apparatus, which has a recording head for ejecting ink from an ink reservoir and driving signal generating means for generating a driving signal for ejecting ink droplets, characterized in that it comprises: an ink reservation amount obtaining means for obtaining an ink reservation amount in the ink reservoir; temperature information storing means for storing head temperature information from temperature detecting means for detecting a temperature of the recording head; temperature change amount obtaining means for obtaining a temperature change amount of the recording head based on the head temperature information stored by the temperature information storing means; and driving signal correction means for correcting the driving signal generated from the driving signal generating means, in which the driving signal correction means corrects the driving signal based on the temperature change amount obtained by the temperature change amount obtaining means and the ink reservation amount obtained by the ink reservation amount obtaining means.

[0010]

The invention described in claim 2 is the ink-jet recording apparatus according to claim 1, characterized in that the temperature information storing means stores the recording head temperature information from the time when a power source is turned on.

[0011]

The invention described in claim 3 is the ink-jet recording apparatus according to claim 1 or 2, characterized in that the

temperature information storing means stores the head temperature information in a waiting state of a recording operation.

[0012]

The invention described in claim 4 is the ink-jet recording apparatus according to any one of claims 1 to 3, characterized in that the temperature information storing means keeps the stored head temperature information even after the power source is turned off.

[0013]

The invention described in claim 5 is the ink-jet recording apparatus according to claim 4, characterized in that the temperature change amount obtaining means obtains the temperature change amount by using the head temperature information kept by the temperature information storing means when the power source is turned on again within a specified time after the power source is turned off.

[0014]

The invention described in claim 6 is the ink-jet recording apparatus according to any one of claims 1 to 5, in which the driving signal generating means generates the driving signal including a driving pulse for ejecting ink droplets, and the driving signal correction means sets a driving voltage of the driving pulse based on the temperature change amount and the ink reservation amount.

[0015]

The invention described in claim 7 is the ink-jet recording

apparatus according to any one of claims 1 to 6, in which the driving signal generating means generates the driving signal including the driving pulse for ejecting the ink droplets, and the driving signal correction means changes a waveform of the driving pulse based on the temperature change amount and the ink reservation amount.

[0016]

[Embodiments of the Invention]

Embodiments of the present invention will be described in detail with reference to the drawings as follows.

[0017]

Fig. 1 is a perspective view of an ink-jet printer 1 that is a representative ink-jet recording apparatus.

[0018]

In the ink-jet printer 1, a carriage 2 is movably installed on a guide member 3, and the carriage 2 is connected to a timing belt 6 that is hooked on a driving pulley 4 and a free rotating pulley 5. The driving pulley 4 is joined to the rotation axis of a pulse motor 7, and the carriage 2 is made to move (main scanning) in a width direction of a recording paper 8 by drive of the pulse motor 7.

[0019]

At an opposing surface (a bottom surface) to the recording paper 8 of the carriage 2, a recording head 11 is installed. The recording head 11 ejects ink supplied from an ink cartridge 12 (a kind of ink reservoir of the present invention) mounted on the carriage 2 or ink supplied from an ink tank (a kind of

ink reservoir of the present invention, not shown) connected via an ink supplying tube from a nozzle orifice 13 (see Fig. 2) as ink droplets.

[0020]

In addition, the carriage 2 is attached with a head substrate (not shown), on which various elements for driving the recording head 11, a temperature sensor 14 (see Fig. 3) or the like are mounted. The above-described temperature sensor 14 functions as the temperature detecting means of the present invention, and it is constituted of, for example, a temperature sensitive element for detecting temperature such as a thermistor. The temperature sensor 14 detects environmental temperature in the vicinity of the recording head 11, and outputs it as head temperature information.

[0021]

In an edge portion area outside a recording area that is within a moving range of the carriage 2, a home position and a waiting position of the carriage 2 are set.

[0022]

The home position is a place where the recording head 11 moves to when a power source is turned off or recording is not performed for a long period of time. When the recording head 11 is positioned in the home position, a cap member 15 of a capping mechanism closes the nozzle orifice 13.

[0023]

The waiting position is a starting position of the recording head 11 when scanning is performed. In other words,

the recording head 11 normally waits at the waiting position, and, at the time of a recording operation, the recording head 11 scans from the waiting position to the recording area, and then it returns to the waiting position when the recording operation ends. Additionally, a wiper member 16 of a cleaning mechanism is disposed under the waiting position.

[0024]

The printer 1 constructed as described above, at the time of the recording operation, ejects the ink droplets from the recording head 11 while synchronizing with the main scanning of the carriage 2, rotates a platen 17 linking with reciprocative movement of the carriage 2, and moves the recording paper 8 in a paper feeding direction (that is, sub-scanning). As a result, images and characters based on printing data are recorded on the recording paper 8.

[0025]

Description will now be made for the recording head 11.

[0026]

The recording head 11 as shown in Fig. 2 comprises an ink chamber 21, where the ink from the ink cartridge 12 is supplied, a nozzle plate 22 where a plurality (for example, 64) of nozzle orifices 13 are arranged in the sub-scanning direction, and a pressure chamber 24, which is provided in plural numbers corresponding to the respective nozzle orifice 13, that expands/contracts due to deformation of a piezoelectric oscillator 23. Then, the ink chamber 21 and the pressure chamber 24 are communicatively connected with an ink supply orifice 25

and a supplying side communicating bore 26, and the pressure chamber 24 and the nozzle orifice 13 are communicatively connected with a first nozzle communicating bore 27 and a second nozzle communicating bore 28. In other words, a series of ink flowpaths from the ink chamber 21 to the nozzle orifice 13 through the pressure chamber 24 is formed for each nozzle orifice 13.

[0027]

The above-mentioned piezoelectric oscillator 23 is so-called a piezoelectric oscillator 23 of warp vibration mode. When the piezoelectric oscillator 23 of warp vibration mode is used, charging the piezoelectric oscillator 23 leads to contraction of the piezoelectric oscillator 23 in an orthogonal direction of the electric field to allow the pressure chamber 24 contract. When the charged piezoelectric oscillator 23 is discharged, the piezoelectric oscillator 23 expands in the orthogonal direction of the electric field to allow the pressure chamber 24 to expand.

[0028]

In the recording head 11, since capacity of the corresponding pressure chamber 24 changes accompanied with charge/discharge of the piezoelectric oscillator 23, the ink droplets can be ejected from the nozzle orifice 13 by utilizing pressure fluctuation of the pressure chamber 24.

[0029]

Note that, alternative to the above-described piezoelectric oscillator 23 of warp vibration mode, a piezoelectric oscillator of so-called vertical vibration mode

may be used. The piezoelectric oscillator 23 of vertical vibration mode is a piezoelectric oscillator 23 that expands the pressure chamber 24 by deformation due to charge and contracts the pressure chamber 24 by deformation due to discharge.

[0030]

Next, electric constitution of the printer 1 will be described. As shown in Fig. 3, this printer 1 comprises a printer controller 31 and a printing engine 32.

[0031]

First, description will be made for the printer controller 31.

[0032]

The printer controller 31 comprises: a sensor interface 33 (hereinafter referred to as a sensor I/F 33) for receiving the head temperature information from the above-described temperature sensor 14; an external interface 34 (hereinafter referred to as an external I/F 34) for receiving various data from a host computer (not shown) and the like; a RAM 35 for temporarily storing various data; a backup memory 36 having a holding function for stored information; a ROM 37 storing a control program and the like; a control section 38 that is constituted by including such things as a CPU; an oscillation circuit 39 for generating a clock signal; a driving signal generating circuit 40 for generating a driving signal to be supplied to the recording head 11; a power source generating section 41 for generating a power source to be used in the driving signal generating circuit 40; and an internal interface 42

(hereinafter referred to as an internal I/F 42) for transmitting the driving signal, dot pattern data (print data), based on the printing data, and the like to the printing engine 32.

[0033]

The sensor I/F 33 receives the head temperature information that was detected by the temperature sensor 14 and converted into a digital quantity by an A/D converter 45 (an analog/digital converter).

[0034]

The external I/F 34 receives the printing data, which is constituted of, for example, a character code, a graphic function, image data and the like, from the host computer or the like. In addition, a busy signal (BUSY) and an acknowledge signal (ACK) are outputted to the host computer or the like via the external I/F 34.

[0035]

The RAM 35 functions as a receiving buffer, an intermediate buffer, an output buffer and a working memory (not shown). The receiving buffer temporarily stores the printing data received via the external I/F 34, the intermediate buffer stores intermediate code data converted by the control section 38, and the output buffer stores the dot pattern data. The dot pattern data is constituted of the print data that is obtained by decoding (translating) gradation data.

[0036]

The backup memory 36 functions as the temperature information storing means of the present invention, and comprises

a storing section 46 for storing the head temperature information obtained via the sensor I/F 33 and a power source supply section 47 constituted of a secondary battery, a capacitor and the like. The power source supply section 47 functions as power source supply means, and supplies a backup power source to the storing section 46 in order to keep stored contents even during the time when the main power source of the printer 1 is turned off.

[0037]

Note that the backup memory 36 is not limited to the one constituted of the storing section 46 and the power source supply section 47, but may be constituted of non-volatile memory such as an EEPROM.

[0038]

The ROM 37 stores the control program (control routine) for performing various data processing, font data, the graphic function and the like. The ROM 37 also functions as signal correction information storing means, and stores driving signal adjusting data (signal correction information) for correcting a driving voltage (a wave height value) and a waveform of a driving pulse constituting the driving signal according to the head temperature information value (ink temperature).

[0039]

The control section 38, other than performing various kinds of controls, reads out the printing data in the receiving buffer, and allows the intermediate buffer to store the intermediate code data obtained by converting the read printing data. The control section 38 also analyzes intermediate code data read

from the intermediate buffer, refers to the font data and the graphic function and the like stored in the ROM 37, then develops it into the dot pattern data. And then, the control section 38 allows the output buffer to store the dot pattern data after necessary decoration processing is executed.

[0040]

When the dot pattern data for one line that can be recorded by one main scanning of the recording head 11 is obtained, the dot pattern data for the one line is sequentially outputted from the output buffer to the recording head 11 via the internal I/F 42. And, when the dot pattern data for the one line is outputted from the output buffer, the already developed intermediate code data is deleted from the intermediate buffer, then development processing for the next intermediate code data is performed.

[0041]

In addition, the control section 38 functions as ink reservation amount obtaining means (residual ink amount obtaining means) of the present invention and obtains an ink reservation amount in the ink cartridge 12 (that is, a residual ink amount) based on an ink ejection amount and the like.

[0042]

For example, replacement of a new ink cartridge 12, ink refill into an ink tank or the like is recognized based on an input signal from a maintenance switch (not shown), and ink reservation amount information is reset when the ink cartridge 12 is replaced or ink refill into the ink tank is performed. Here, initial ink amount information such as content of the ink

cartridge 12 or filled-up content of the ink tank is stored in the backup memory 36 as the ink reservation amount information.

[0043]

Next, the ink ejection amount accompanied with a recording operation, a flushing operation and the like is recognized one by one by counting the number of ink droplets ejection, the ink reservation amount (the residual ink amount) is obtained by subtracting the ink ejection amount from the initial ink amount information.

[0044]

Further, the control section 38 performs control such that the head temperature information inputted from the temperature sensor 14 via the A/D converter 45 is stored in the backup memory 36. For example, the head temperature information from the temperature sensor 14 is stored in the backup memory 36 every time after a certain period of time passes.

[0045]

Then, the control section 38 also functions as temperature change obtaining means of the present invention, and obtains a temperature change amount of the recording head 11 based on the head temperature information stored in the backup memory 36.

[0046]

Furthermore, the control section 38 functions as driving signal correction means of the present invention, and selects correction data from driving signal correction data stored in the ROM 37, and performs a processing to output a control signal

(driving signal correction information) to the driving signal generating circuit 40 based on the temperature change amount of the recording head 11 and the ink reservation amount in the ink cartridge 12.

[0047]

The driving signal generating circuit 40 functions as driving signal generating means of the present invention, and generates the driving signal for activating the piezoelectric oscillator 23 of the recording head 11. For example, the circuit generates the driving signal (COM) in which a plurality of driving pulses is connected in series as shown in Fig. 6 (a).

[0048]

The exemplified driving pulse is constituted of: an expansion element (discharge pulse) P1 in which electric potential changes by descending from the middle potential V_m to the lowest potential V_L in a constant slope; a first holding element (holding pulse) P2 that keeps the lowest potential V_L ; an ejection element (charge pulse) P3 in which electric potential ascends from the lowest potential V_L to the highest potential V_P in a specified steep slope; a second holding element P4 that keeps the highest potential V_P ; and a damping element P5 in which electric potential changes by descending from the highest potential V_P to the middle potential V_m in a specified slope.

[0049]

When the above-described expansion element P1 is applied to the piezoelectric oscillator 23, the piezoelectric oscillator 23 deforms in a direction that it expands the volume of the pressure

chamber 24, and generates a negative pressure in the pressure chamber 24. The expanded state of the pressure chamber 24 is kept while the first holding element P2 is being applied. The ejection element P3 is supplied following the first holding element P2. When the ejection element P3 is supplied, the piezoelectric oscillator 23 deforms such that the pressure chamber 24 rapidly contracts. The contraction of the pressure chamber 24 allows ink pressure in the pressure chamber 24 to increase, and the ink droplets are ejected from the nozzle orifice 13. The contracted state of the pressure chamber 24 is kept while the second holding element P4 is being supplied. Thereafter, the damping element P5 is supplied to the piezoelectric oscillator 23 in order to terminate vibration of a meniscus (free surface of the ink exposed at the nozzle orifice 13) in a short time.

[0050]

The driving signal generating circuit 40 also generates the driving signal corrected based on the control signal (the driving signal correction information) outputted from the control section 38. For example, the circuit increases/decreases the driving voltage (the wave height value) V_h and generates the driving signal, the waveform of which is adjusted. Note that the correction of the driving signal will be described later.

[0051]

Next, description will be made for the printing engine 32.

[0052]

The printing engine 32 is constituted of a paper feeding motor 50, the pulse motor 7 and an electric driving system 51 of the recording head 11.

[0053]

The electric driving system 51 of the recording head 11 comprises a shift register circuit 52, a latching circuit 53, a level shifter circuit 54, a switching circuit 55 and the piezoelectric oscillator 23, and they are electrically connected in the order of the shift register circuit 52, the latching circuit 53, the level shifter circuit 54, the switching circuit 55 and the piezoelectric oscillator 23. The shift register circuit 52, the latching circuit 53, the level shifter circuit 54, the switching circuit 55 and the piezoelectric oscillator 23 are provided in plural numbers corresponding to the respective nozzle orifice 13 of the recording head 11.

[0054]

In the electric driving system 51, when the print data added to the switching circuit 55 is "1," the switching circuit 55 becomes in a connected state, and the driving signal (COM) is directly applied to the piezoelectric oscillator 23, and then each piezoelectric oscillator 23 deforms according to the waveform (electric potential) of the driving signal. On the contrary, when the print data added to the switching circuit 55 is "0," the switching circuit 55 becomes in an unconnected state, and supply of the driving signal to the piezoelectric oscillator 23 is cut off.

[0055]

As described above, since the driving signal can be selectively supplied to each piezoelectric oscillator 23 based on the print data, the ink droplets can be selectively ejected from the nozzle orifice 13 depending on the print data.

[0056]

Next, description will be made for operations of the printer 1 mainly with regard to the correction of the driving signal based on the temperature change amount of the recording head 11 and the ink reservation amount of the ink cartridge 12. Herein, Fig. 4 is a flowchart explaining the operation of the printer 1, Fig. 5 is a view explaining the difference of change of the ink temperature accompanied with the ink reservation amount (the residual ink amount), and Fig. 6 is a view explaining the driving pulse constituting the driving signal.

[0057]

When the power source is turned on to the printer 1 (S10), the control section 38 obtains the head temperature information detected by the temperature sensor 14 (S11), and the obtained head temperature information is stored in the backup memory 36 that is the temperature information storing means (S12). In this embodiment, the head temperature information from the time when the power source is turned on is stored in the backup memory 36 as described above.

[0058]

Obtaining processing and storing processing of the head temperature information are repeated every specified period of

time (for example, every one minute) until the printing data (printing signal) from the host computer is received (S13). Accordingly, the head temperature information in a waiting state, where no recording operation is performed, is stored in the backup memory 36 every specified period of time.

[0059]

Upon receiving the above-described printing data, the control section 38 obtains the head temperature information from the temperature sensor 14 (S14), and stores the obtained head temperature information in the backup memory 36 (S15). Thereafter, the control section 38 (the ink reservation amount obtaining means) obtains the ink reservation amount (the residual ink amount) (S16). The ink reservation amount is obtained, for example, by subtracting the ink ejection amount from the initial ink amount information as described above.

[0060]

After the ink reservation amount is obtained, the control section 38 (the driving signal correction means) performs the correction of the driving signal (S17).

[0061]

In the processing of step S17, the control section 38 (temperature change amount obtaining means) first obtains the temperature change amount of the recording head 11, for example, the amount of change of the head temperature information corresponding to a unit time, based on the head temperature information stored in the backup memory 36 (temperature information storing means).

[0062]

Various methods can be used in order to obtain the temperature change amount. For example, the temperature change amount may be calculated by using the head temperature information obtained immediately after the power source was turned on and the latest head temperature information. Alternatively, the temperature change amount may be calculated via the method of least squares by using a plurality of pieces of head temperature information between the head temperature information before a specified time and the latest head temperature information.

[0063]

Upon obtaining the temperature change amount, the control section 38 (ink temperature estimating means) estimates the temperature of ink reserved in the ink cartridge 12 (or ink tank). In this processing, the control section 38, by adding the temperature change amount and the ink reservation amount to the latest head temperature information, estimates the current ink temperature.

[0064]

Specifically, the fact that the temperature change amount is large per unit time means that the environmental temperature (the room temperature) at a place where the printer 1 is used changes substantially in a short period of time. However, temperature changing speed of the ink is slower than that of the environmental temperature due to the difference of heat capacity. Therefore, when the temperature change amount per

unit time is large, the ink temperature is estimated by taking into account that the ink temperature changes more slowly than the head temperature information. For example, in the case where the temperature change amount per unit time is large in a positive direction (+ direction), the ink temperature is set lower than that of the latest head temperature information according to the temperature change amount because the temperature of the recording head 11 (that is, the environmental temperature) is in the state of rapid increase. Conversely, in the case where the temperature change amount per unit time is large in a negative direction (- direction), the ink temperature is set higher than that of the latest head temperature information according to the temperature change amount.

[0065]

On the other hand, the fact that the above-described temperature change amount is constant for a relatively long time (for example approximately one to two hours) means that the environmental temperature is stable at a certain temperature. In such a case, since it is presumed that the ink temperature is substantially the same as the environmental temperature, the ink temperature is made coincident with the latest head temperature information.

[0066]

Degree of change of the ink temperature relative to the environmental temperature differs depending on the ink reservation amount.

[0067]

Here, Fig. 5 is a graph showing change of the ink temperature with the passage of time in the case where three pieces of the ink cartridges 12 with different ink reservation amounts were cooled down until the ink temperature reached 0°C and each ink cartridge 12 was left to stand in an environment of 20°C. In Fig. 5, a line segment added with a "triangle" symbol shows a state where the cartridge is filled with the ink, a line segment added with a "square" symbol shows a state where the ink reservation amount is substantially half of the cartridge volume, and a line segment added with a "circle" symbol shows a state that the ink reservation amount is about one third the cartridge volume.

[0068]

As it is understood from Fig. 5, the less the ink reservation amount in the ink cartridge is, the faster the ink temperature ascends to the environmental temperature. For example, in the ink cartridge 12 with the ink about one third the cartridge volume, the ink temperature ascended to the same degree as the environmental temperature in about thirty minutes after the cartridge was left to stand. On the contrary, in the ink cartridge 12 with the ink about a half the cartridge volume, about sixty minutes were needed until the ink temperature ascended to the same degree as the environmental temperature, and about ninety minutes were needed for the ink cartridge 12 in which the cartridge was filled with the ink.

[0069]

As described above, the more the ink reservation amount

is, the slower the ink temperature changes. Conversely, the less the ink reservation amount is, the faster the ink temperature changes. Therefore, the less the ink reservation amount is, the closer the ink temperature is set to the latest head temperature information.

[0070]

Note that, in the embodiment, the relation between the above-described temperature change amount and the ink reservation amount is stored in the ROM 37 as table information (ink temperature estimating information).

[0071]

After the ink temperature is estimated in such a manner, a driving waveform is corrected based on the ink temperature. In other words, the waveform of the driving voltage V_h (the wave height value) of the driving pulse is changed according to the ink temperature.

[0072]

In this case, the control section 38 refers to the driving signal adjusting data. When the ink temperature is lower than a standard temperature, the driving voltage V_h of the driving pulse is set higher than a reference driving voltage [the driving voltage V_h of the driving pulse in Fig. 6 (a)] in order to make an ejecting force of the ink droplets stronger than usual as shown in Fig. 6 (b). On the contrary, when the ink temperature is higher than the standard temperature, the driving voltage V_h of the driving pulse is set lower than the reference driving voltage as shown in Fig. 6 (c) in order to make the ejecting

force of the ink droplets weaker than usual.

[0073]

Incidentally, when the ejecting force of the ink droplets is changed as described above, flying speed of the ink droplets also changes according to the ejecting force. For example, when the driving voltage V_h is set higher than a reference driving voltage, the flying speed of the ink droplets becomes faster than the reference flying speed, and when the driving voltage V_h is set lower than the reference driving voltage, the flying speed of the ink droplets becomes slower than the reference flying speed.

[0074]

In the embodiment, the flying speed of the ink droplets is made to be coincident with standard speed by correcting the waveform as well.

[0075]

In the case where the driving voltage V_h is set higher than the reference driving voltage, correction of the driving pulse as exemplified in Figs. 7 (a) to (c) is performed in order to decrease the flying speed of the ink droplets. In other words, in Fig. 7 (a), intermediate voltage (V_c) is made lower than a reference intermediate potential [the intermediate potential V_m of the driving pulse in Fig. 6 (a)] by lowering the intermediate potential V_m . In Fig. 7 (b), a voltage slope of the expansion element P1, which allows the pressure chamber 24 to expand, is set gently. In other words, supply time T_{wd1} of the expansion element P1 is set longer than standard supply time. In Fig.

7 (c), the first holding element P2 (a time component T_{wh1}) for holding the expanded state of the pressure chamber 24 is set longer than standard time.

[0076]

On the other hand, in the case where the driving voltage V_h is set lower than the reference driving voltage, correction as shown in Figs. 8 (a) to (c) is performed in order to increase the flying speed of the ink droplets. In other words, in Fig. 8 (a), the intermediate voltage (V_c) is made higher than the reference intermediate potential by increasing the intermediate potential V_m . In Fig. 8 (b), the voltage slope of the expansion element P1, which allows the pressure chamber 24 to expand, is set steep. In other words, the supply time T_{wd1} of the expansion element P1 is set shorter than the standard supply time. In Fig. 8 (c), the first holding element P2 (the time component T_{wh1}) for keeping the expanded state of the pressure chamber 24 is set shorter than the standard time.

[0077]

Note that, in the driving signal correction processing of step S17, although the control section 38 (the driving signal correction means) estimates the ink temperature based on the temperature change amount and the ink reservation amount, and thus the driving waveform is corrected based on the ink temperature, the correction is not limited to this method. Specifically, an appropriate driving signal may be set based on the temperature change amount and the ink reservation amount.

[0078]

For example, a constitution may be taken such that the individual information of the latest temperature change amount, the temperature change amount per unit time and the ink reservation amount and parameter for defining the driving waveform (for example, the intermediate potential, the supply time T_{wd1} of the expansion element, the supply time T_{wh1} of the holding element, the driving voltage V_h and the like) are arranged in a table and stored in the ROM 37, and the driving signal is corrected based on this information.

[0079]

After the driving signal was corrected as described above, recording operation for one path (for one line) is performed by using the corrected driving signal (S18). In the recording operation, since the ink droplets are ejected by using the driving pulse of which the driving voltage is adjusted according to the ink temperature, the ejected amount of the ink droplets can be made constant even in a state where the temperature change amount per unit time is large because the environmental temperature is rapidly changed. Accordingly, image quality of a recorded image can be stabilized.

[0080]

After recording for one path is completed, an evaluation is made to check for the existence of printing data of a following line (S19). Here, when the printing data for a following line exists, processing proceeds to step S14 described above for repeating the above-described recording operations (S14 to S19). On the other hand, when no printing data exists, processing

proceeds to step S11, and the head temperature information in the waiting state is obtained every specified period of time until the printing data is received (S11 to S13).

[0081]

As described above, in the embodiment, the temperature of the recording head 11 is stored every specified period of time from the time when the power source is turned on, and the correction of the driving signal is performed based on the temperature change amount and the ink reservation amount prior to printing for one line. Therefore, an appropriate driving signal can be set for each occasion of recording of every line, and thus an image of stable image quality can be recorded even if the room temperature is rapidly changed.

[0082]

In addition, since the amount of the ink droplets can be made constant regardless of the change of the environmental temperature, the ink reservation amount can be accurately grasped. As a result, a blank printing phenomenon whereby printing operation is performed despite ink in the ink cartridge 12 or the ink tank having run out, or a failure of replacement order for the cartridge or ink filling order where orders are made despite sufficient ink being reserved in the ink cartridge 12 or the ink tank, can be surely prevented.

[0083]

Note that, in the embodiment, although the correction of the driving signal based on the temperature change amount and the ink reservation amount is performed prior to recording for

one line, correction timing is not limited to this. For example, the driving signal may be corrected prior to recording for one page.

[0084]

Additionally, an obtaining interval for the head temperature information is set at one minute, but the interval is not limited to this; the interval may be set at an optional time. For example, the head temperature information may be obtained every ten minutes.

[0085]

Further, regarding the ink reservation amount, obtaining of the ink reservation amount will suffice. Thus, a residual ink amount sensor for directly detecting the ink amount in the ink cartridge 12 may be provided, and the ink reservation amount may be detected based on a detecting signal from the residual ink amount sensor. Alternatively, with regards to resetting the ink reservation amount, a cartridge sensor for detecting mounting of the ink cartridge 12 may be provided on carriage 2, replacement of the ink cartridge 12 may be detected based on a detecting signal from the cartridge sensor, and the ink reservation amount may be automatically reset accompanied by the replacement.

[0086]

Incidentally, in the above-described embodiment, the temperature change amount is obtained by using the head temperature information after the power source of the printer 1 is turned on, and the correction of the driving signal is

performed. However, in the case where the power source is turned on again in a relatively short time after the power source of the printer 1 is turned off, the correction of the driving signal can be performed with a higher accuracy by using the head temperature information that was stored thus far.

[0087]

Next, description will be made for another embodiment constituted as described above. Fig. 9 is a flowchart explaining an operation of the ink-jet printer 1 in the embodiment. Note that, in the flowchart, the same step number is assigned to the same processing as that of the preceding embodiment (Fig. 4).

[0088]

When the power source to the printer 1 is turned on (S10), the control section 38 evaluates whether a specified period of time (for example ten minutes) has passed or not since the power source was last turned off (S21).

[0089]

The evaluation is performed, for example, based on measurement information from a timer (not shown). The timer functions as a disconnection time measuring means, operates by an exclusive power source such as a secondary battery, and thus the timer performs measurement operation during the time when the power source of the printer 1 is turned off.

[0090]

The control section 38 obtains the measurement information from the timer immediately before the power source is turned off, and stores the obtained measurement information in the

backup memory 36. Then, the control section 38 also obtains the measurement information from the timer the next time the power source is turned on. Then, a passage of time from the previous point of turning off the power source is obtained by comparing the measurement information when the power source was turned off, that is stored in the backup memory 36, with the measurement information when the power source is turned on which is obtained at this time.

[0091]

In the case where the obtained passage of time is equal to a specified period of time or less, in other words, a main power source is turned on again in a short time after the main power source of the printer 1 was turned off, the head temperature information is obtained from the temperature sensor 14 (S11) while the head temperature information stored in the backup memory 36 is being kept (S22). And then, the obtained temperature information is stored in the backup memory 36 as the temperature information storing means (S12). Therefore, in this case, the head temperature information after the power source is turned on is stored in the backup memory 36 following the already obtained head temperature information.

[0092]

Upon receiving the printing data (S13), the control section 38 obtains the head temperature information (S14), stores it in the backup memory 36 (S15), and obtains the ink reservation amount (S16).

[0093]

After the ink reservation amount is obtained, the control section 38 (the driving signal correction means) corrects the driving signal (S17). In the correction processing, the control section 38 (temperature change amount obtaining means) obtains the temperature change amount by using the head temperature information obtained a little before the power source is turned on in addition to the head temperature information obtained after the power source is turned on. Then, the driving signal is corrected based on the amount of temperature change thus obtained. Accordingly, a more accurate temperature change amount can be obtained. Thus, the correction of the driving signal can be performed even more effectively.

[0094]

After the driving signal is corrected, the recording operation is performed (S18), an evaluation is made whether or not there is any subsequent printing data (S19), and the above-described processing (processing from S11, or from S14) is repeated according to the result of this evaluation.

[0095]

On the other hand, in the above-described processing of step S21, when it is judged that the passage of time exceeded the specified period of time, the head temperature information stored in the backup memory 36, that is, the head temperature information obtained prior to turning off the power source is discarded (S23). Then, the processing proceeds to step S11 to perform the above-described processing. In this case, the operation will be the same as that of the above-described

embodiment.

[0096]

As has been described, in the embodiment, in the case where the power source is turned on again in a relatively short time after the main power source of the printer 1 was turned off, the driving signal is corrected by using the head temperature information obtained before the power source was turned off. With this correction, when the power source is turned on again after a relatively short time, the correction of the driving signal can be performed by using additional head temperature information. As a result, the correction of the driving waveform can be performed more effectively, and further stabilization of image quality can be achieved.

[0097]

Incidentally, each of the above embodiments has a constitution such that the head temperature information is obtained every specified period of time, beginning from the time when the power source of the printer 1 is turned on. The head temperature information, however, may be obtained with the recording operation.

[0098]

Next, description will be made for another embodiment constituted as described above with reference to a flowchart in Fig. 10.

[0099]

When the power source is turned on to the printer 1 (S30), processing proceeds to a standby state (S31). In the standby

state, the control section 38 obtains the head temperature information from the temperature sensor 14 as initial temperature information, and stores the obtained head temperature information in the backup memory 36 as the temperature information storing means.

[0100]

Thereafter, the control section 38 monitors the printing data, and waits until the printing data is received (S32). Upon receiving the printing data, the control section 38 obtains the head temperature information (S33), and stores the obtained head temperature information in the backup memory 36 (S34).

[0101]

After the head temperature information is stored in the backup memory 36, the control section 38 obtains the ink reservation amount (the residual ink amount) in the ink cartridge 12 (S35), and corrects the driving signal (S36). In the correction processing, the temperature change amount of the recording head 11 is obtained based on the latest head temperature information and the head temperature information obtained before the latest information. Then, the driving signal is corrected based on the obtained temperature change amount and the ink reservation amount. Note that, in the initial recording operation after turning on the power source of the printer 1, the temperature change amount is obtained by using the head temperature information obtained in the standby state.

[0102]

After the driving signal is corrected, recording for one

line is performed by the corrected driving signal (S37). In this recording operation, also, recording is performed with an appropriate ink amount in consideration of the ink temperature, similar to each aforementioned embodiment.

[0103]

When the recording operation is completed, the control section evaluates whether or not there is any subsequent printing data (S38), and repeats the above-described processing according to the evaluation result. Here, when subsequent printing data does not exist, the processing proceeds to step S32 and waits until subsequent printing data is received. On the other hand, when subsequent printing data exists, the processing proceeds to step S33 to obtain the head temperature information, and the head temperature information obtained in step S34 is stored in the backup memory 36. And then, the driving waveform is corrected by using the obtained head temperature information (S36).

[0104]

As described above, in the embodiment, every time the printing data is inputted, in other words, every time the recording operation for the one line is performed, the head temperature information is obtained prior to the recording operation, and the obtained head temperature information is stored in the backup memory 36 (the temperature information storing means). Accordingly, when a constitution is made such that the head temperature information is obtained corresponding to the recording operation for one line and stored in the backup memory 36, the amount of the head temperature information to

be stored in the backup memory 36 can be reduced while appropriately correcting the driving signal.

[0105]

Based on a similar conception, the head temperature information may be obtained prior to the recording operation every time the recording for one page is executed and stored in the backup memory 36.

[0106]

Note that various additions and changes within the scope of the present invention as described above can be made.

[0107]

Forexample, the ink-jet recording apparatus is not limited to an ink-jet recording apparatus having the recording head including the piezoelectric oscillator as a pressure generating element, and an ink-jet recording apparatus having the recording head including a magnetostrictive element as a pressure generating element may be used.

[0108]

Alternatively, a heating element may be used as the pressure generating element. A similar effect can be obtained with an ink-jet recording apparatus including a recording head that ejects ink droplets by expanding/contracting bubbles in the pressure chamber via heat generated by the heating element.

[0109]

[Effect of the Invention]

As described above, according to the present invention, the driving signal correction means is provided for correcting

the driving signal, which is generated from the driving signal generating means based on the temperature change amount obtained by the temperature change amount obtaining means and the ink reservation amount obtained by the ink reservation amount obtaining means. The current ink temperature can be grasped based on the temperature change amount even if the temperature of the ink in the ink reservoir is changed later than the environmental temperature when the environmental temperature is largely changed in a short time. Thus, the driving signal suitable for the ink temperature can be set.

[0110]

As described above, even when the environmental temperature is greatly changed in a short time due to the operation of an air conditioner and so on, the ejection amount of the ink droplets can be made to be constant irrespective of the change of the environmental temperature. As a result, the image quality can be stabilized.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a perspective view explaining a printing mechanism of an ink-jet printer.

[Fig. 2] Fig. 2 is a view showing a mechanical structure of a recording head.

[Fig. 3] Fig. 3 is a block diagram explaining an electrical constitution of the ink-jet printer.

[Fig. 4] Fig. 4 is a flowchart explaining an operation of a first embodiment.

[Fig. 5] Fig. 5 is a graph illustrating a relation between standing time and ink temperature in an ink cartridge.

[Fig. 6] Figs. 6 (a) to 6 (c) are views explaining a driving pulse constituting a driving signal: Fig. 6 (a) shows a standard driving pulse; Fig. 6 (b) a driving pulse having a driving voltage set high; and Fig. 6 (c) a driving pulse having a driving voltage set low.

[Fig. 7] Figs. 7 (a) to 7 (c) are views explaining correction of the driving signal: Fig. 7 (a) shows a driving pulse having an intermediate voltage set low; Fig. 7 (b) a driving pulse having a voltage slope of an expansion element set gentle; and Fig. 7 (c) a driving pulse having a first holding element set long.

[Fig. 8] Fig. 8 (a) to 8 (c) are views explaining the correction of the driving signal: Fig. 8 (a) shows a driving pulse having an intermediate voltage set high; Fig. 8 (b) a driving pulse having a voltage slope of the expansion element set large; and Fig. 8 (c) a driving pulse having the first holding element set short.

[Fig. 9] Fig. 9 is a flowchart explaining an operation in another embodiment.

[Fig. 10] Fig. 10 is a flowchart explaining an operation in another embodiment.

[Explanation of Reference Numerals]

1. Ink-jet printer
2. Carriage
3. Guide member
4. Driving pulley

5. Free rotating pulley
6. Timing belt
7. Pulse motor
8. Recording paper
11. Recording head
12. Ink cartridge
13. Nozzle orifice
14. Temperature sensor
15. Cap member
16. Wiper member
17. Platen
21. Ink chamber
22. Nozzle plate
23. Piezoelectric oscillator
24. Pressure chamber
25. Ink supply orifice
26. Supplying side communicating bore
27. First nozzle communicating bore
28. Second nozzle communicating bore
31. Printer controller
32. Printing engine
33. Sensor interface
34. External interface
35. RAM
36. Backup memory
37. ROM
38. Control section

- 39. Oscillation circuit
- 40. Driving signal generating circuit
- 41. Power source generating section
- 42. Internal interface
- 45. A/D converter
- 46. Storing section
- 47. Power source supply section
- 50. Paper feeding motor
- 51. Electric driving system of recording head
- 52. Shift register circuit
- 53. Latching circuit
- 54. Level shifter circuit
- 55. Switching circuit

[Name of Document] Abstract

[Abstract]

[Subject] Disclosed is an ink-jet recording apparatus, which is capable of making an ejection amount of ink droplets constant even when a temperature change occurs in a place where the ink-jet recording apparatus is used, and performing recording with stable image quality.

[Solving Means] A temperature change amount of a recording head is obtained based on head temperature information stored in a backup memory (S17), an ink reservation amount in an ink cartridge is obtained (S16), and a driving signal is corrected based on the amount of temperature change and the ink reservation amount (S17).

[Selected Drawing] Fig. 4

FIG. 3

7. PULSE MOTOR
14. TEMPERATURE SENSOR
23. PIESOELECTRIC OSCILLATOR
35. RAM, RECEIVING BUFFER, INTERMEDIATE BUFFER, OUTPUT BUFFER
36. BACKUP MEMORY
38. CONTROL SECTION
39. OSCILLATION CIRCUIT
40. DRIVING SIGNAL GENERATING CIRCUIT
41. POWER SOURCE GENERATING SECTION
45. A/D CONVERTER
46. STORING SECTION
47. POWER SOURCE SUPPLY SECTION
50. PAPER FEEDING MOTOR
52. SHIFT REGISTER CIRCUIT
53. LATCHING CIRCUIT
54. LEVEL SHIFTER CIRCUIT
55. SWITCHING CIRCUIT
POWER SOURCE

FIG. 4

S10 POWER SOURCE IS TURNED ON.
S11 HEAD TEMPERATURE IS DETECTED.
S12 DATA IS STORED.
S13 WHETHER OR NOT PRINTING SIGNAL EXIST?
S14 HEAD TEMPERATURE IS DETECTED.
S15 DATA IS STORED.

S16 INK CARTRIDGE RESIDUAL AMOUNT IS DETECTED.
S17 DRIVING WAVEFORM IS SET BY OPERATION.
S18 PRINTING FOR ONE PATH IS PERFORMED.
S19 WHETHER OR NOT PRINTING SIGNAL EXIST?

FIG. 5

RELATION BETWEEN TIME AND INK TEMPERATURE (TIME CHANGE $\Delta T=20^{\circ}\text{C}$)
INK TEMPERATURE
TIME

FIG. 9

POWER SOURCE IS TURNED OFF.
S10 POWER SOURCE IS TURNED ON.
S21 WHETHER OR NOT CERTAIN PERIOD OF TIME PASSED AFTER POWER
SOURCE IS TURNED OFF?
S22 KEEP TEMPERATURE DATA.
S23 DISCARD TEMPERATURE DATA.
S11 HEAD TEMPERATURE IS DETECTED.
S12 DATA IS STORED.
S13 WHETHER OR NOT PRINTING SIGNAL EXIST?
S14 HEAD TEMPERATURE IS DETECTED.
S15 DATA IS STORED.
S16 INK CARTRIDGE RESIDUAL AMOUNT IS DETECTED.
S17 DRIVING WAVEFORM IS SET BY OPERATION.
S18 PRINTING FOR ONE PATH IS PERFORMED.
S19 WHETHER OR NOT PRINTING SIGNAL EXIST?

FIG. 10

S30 POWER SOURCE IS TURNED ON.

S31 STAND-BY.

S32 PRINTING SIGNAL IS RECEIVED.

S33 HEAD TEMPERATURE IS DETECTED.

S34 DATA IS STORED.

S35 INK CARTRIDGE RESIDUAL AMOUNT IS DETECTED.

S36 DRIVING WAVEFORM IS SET BY OPERATION.

S37 PRINTING FOR ONE PATH IS PERFORMED.

S38 WHETHER OR NOT PRINTING SIGNAL EXIST?